Resource

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FEATURES

Center-Pivot Automation

Using crop canopy temperature to eliminate irrigation guesswork

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Center pivots revolutionized irrigation, not only because they improved water-use efficiency, but because they reduced labor and management needs. Irrigation scientists have done an outstanding job of developing accurate methods of determining when to water and how much. However, these methods are often too complicated and/or expensive for most busy irrigators to bother with. This "hassle factor" deters many irrigators from adopting more advanced irrigation scheduling techniques. The resultant lack of implementation not only contributes to water scarcity problems, but since nutrients move mainly with water, it also is a significant contributor to water quality problems.

Many more irrigators will adopt data-based irrigation scheduling technologies when they not only conserve water and resources, but simplify irrigation management instead of complicating it. Automation of irrigation scheduling using feedback data from the crop or soil holds the promise of simplifying the lives of busy irrigation managers while scheduling irrigations in such a way that water and fertilizer are conserved.

TTT and IRTs

Although soil moisture measurements can be used as the data feedback necessary to automate irrigation scheduling, a drawback is that most sensors under row crops must be removed every season to harvest, work the ground, and replant. Researchers at the USDA-ARS research station in Bushland, Texas have been working to develop and test automatic irrigation scheduling technologies for center pivots using crop leaf temperature. A system was created to apply the time temperature threshold (TTT) method of irrigation scheduling to center pivots using sensors mounted on the pivots themselves. The TTT method involves using infrared thermometers (IRTs) to remotely examine crop canopy temperatures over the course of a day. If a threshold canopy temperature is exceeded for longer than a predetermined threshold time, an irrigation event is scheduled. This method has been shown to give equivalent or better yields and water use efficiency (WUE) as a weekly replenishment of soil water deficiency, measured using neutron probe soil profile moisture measurements, in multiple-year experi-

Infrared thermometers (IRTs) are mounted on the trusses of a center pivot.

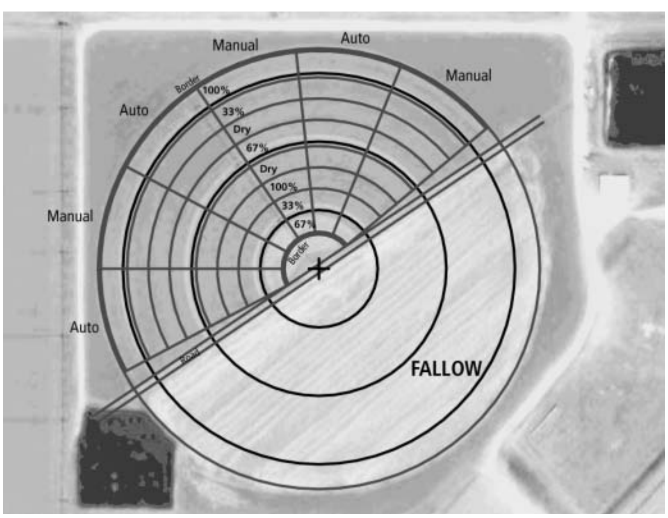
ments on a variety of crops under drip irrigation in the high plains region of Texas.

Overcoming the obstacles

Applying the TTT method using IRTs mounted on self-propelled irrigation systems such as center pivots or linear moves presents special challenges. First, it requires a means of estimating the diurnal canopy temperature dynamics using only a one-time-of-day canopy temperature measurement. Secondly, it requires a method of automatically collecting and analyzing the canopy temperature data and controlling the moving irrigation system based on the data analysis.

Determining the curve

A method of determining the diurnal canopy temperature curve using a one-time-of-day temperature measurement and a reference temperature curve was developed and tested. The mean absolute error from "calculated to observed" was approximately 0.5°C (0.9°F) from 0800 h to 2200 h. Data collection, analysis, and pivot automation was accomplished using an array of 16 IRTs connected to a data logger and mounted on a three-tower center pivot (as shown above). A separate array of IRTs was located in stationary positions in the field and also connected to a data logger. Spread spectrum (900 MHz) radios were used to communicate between a desktop computer located in a nearby building and the data loggers as well as the pivot control panel. Using scheduled data collection intervals, this computer was able to collect the canopy temperature data, analyze it, determine need for an irrigation event, and issue control commands, thus completely automating the center pivot. Only half of the pivot circle was used allowing the other half to be planted to a cover crop to even out the previous season's irrigation treatments. This half was divided into six wedges which were alternatively designated as manual and automatic (as shown below) so that the automatic irrigation scheduling could be compared to manual irrigation scheduling using soil profile moisture measurements from a neutron probe. Two different replications of four different irrigation treatments (dry, 33 percent, 66 percent, and 100 percent of full irrigation) were applied radially out from the center point with the second tower wheel track serving as a block demarcation line.



A center-pivot automation plot plan.

Decisions, decisions, decisions

Automated irrigation decisions were made shortly after midnight. If the pivot was stationary the previous day, then the canopy temperature data from the spot where the pivot was resting was used to make the irrigation decision. If the pivot was irrigating the previous day, then a weighted average of the signals from the whole field was used for the irrigation decision. The pivot's position was reported by a differentially corrected global positioning satellite (GPS) receiver mounted past the end tower. The position information was collected by the control computer every minute, and the instructions were sent to the pivot accordingly to control the complex motion of the pivot required to irrigate every other pie-slice.

Mapping the temps

Co-author Troy Peters checks communications via the pivot control panel.

As a side benefit, a canopy temperature map can be created as the pivot moves over the canopy. Since canopy temperature can indicate water, disease, or pest stress, additional research is being done to determine whether these maps may be able to identify problem areas of the field. This mapping is able to identify field variability not only on a spatial scale but, since the pivot moves at fairly regular intervals throughout the season, on a temporal scale as well. Because of this, it has potential applications for the feedback and control required for site-specific irrigation or chemigation, and it provides useful visual feedback for the irrigation manager.

Conquering conjecture, eliminating estimation

The center pivot is completely automated; and additional data about the crop's status is made available on both a spatial and temporal scale. This system has the potential to free up producers' time, increase yields with less water, and help producers identify problems in their fields as they arise. More than anything, it is hoped that this system can help take the guesswork out of irrigation. R

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